Demonstrate Vertical Take Off and Landing (VTOL), Fixed Wing (FW) Flight Technology from a NOAA ship

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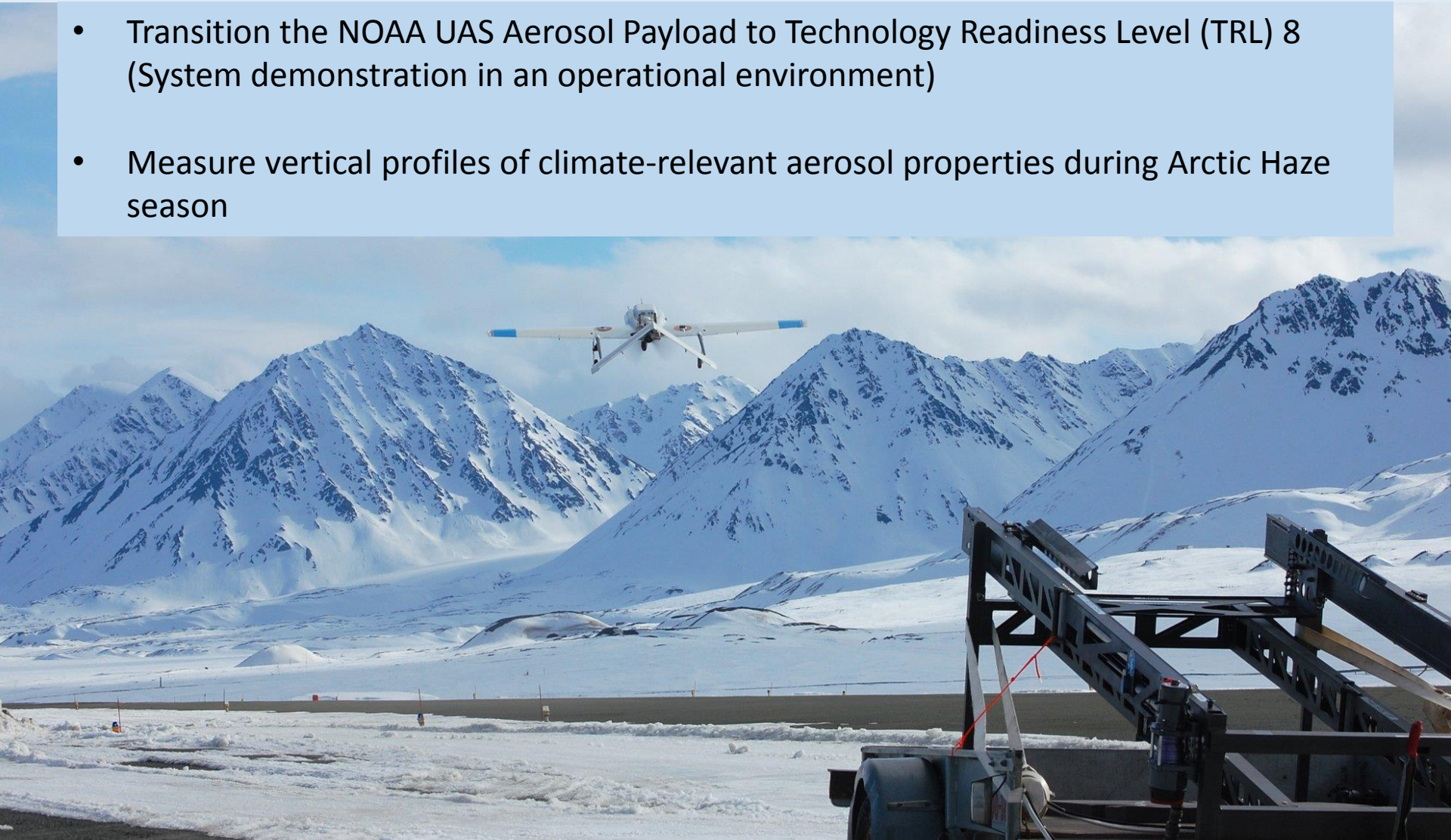
NOAA PMEL UAS Measurements
Svalbard, Norway - April 2011 & 2015
Objectives

- Transition the NOAA UAS Aerosol Payload to Technology Readiness Level (TRL) 8 (System demonstration in an operational environment)
- Measure vertical profiles of climate-relevant aerosol properties during Arctic Haze season

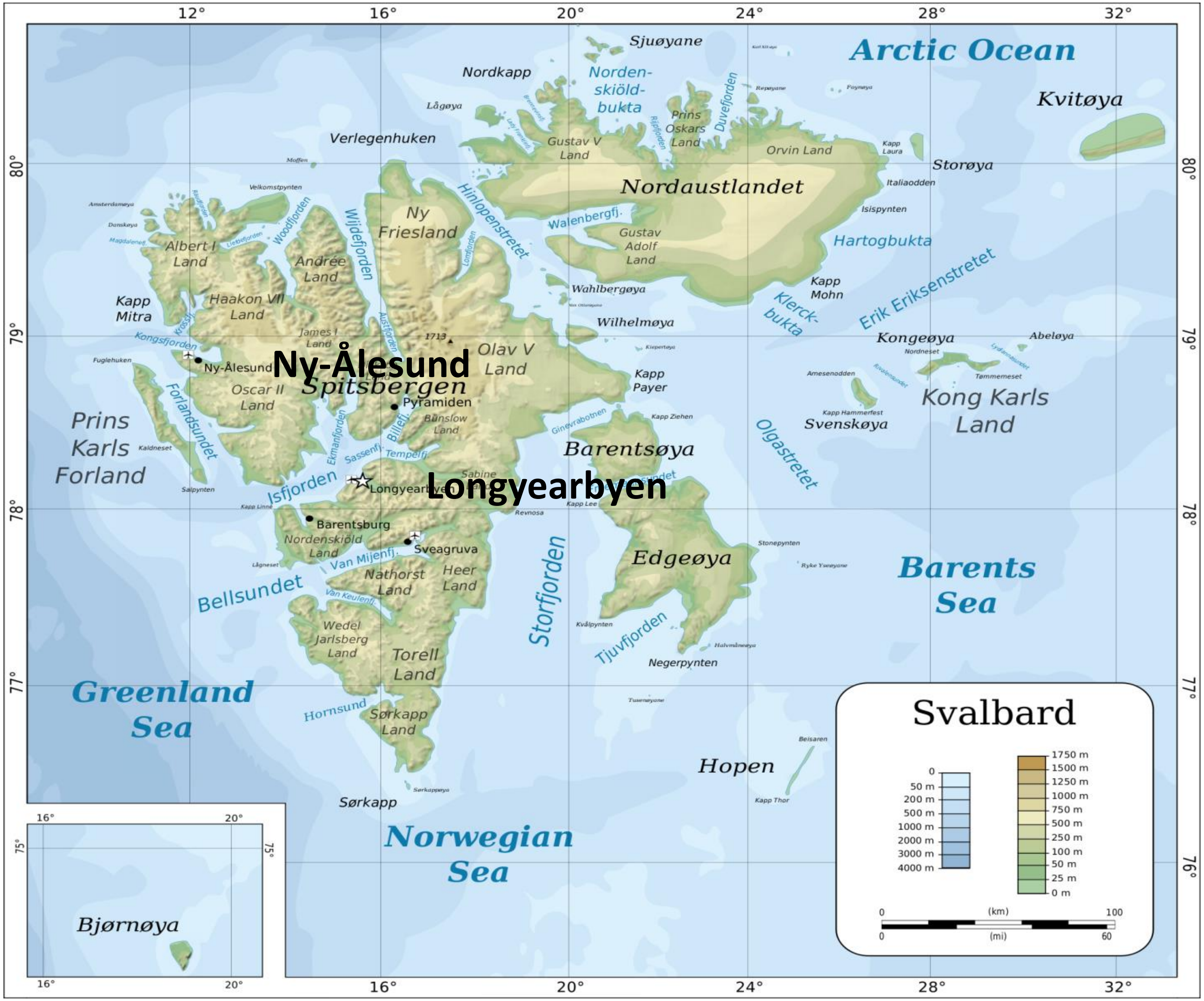


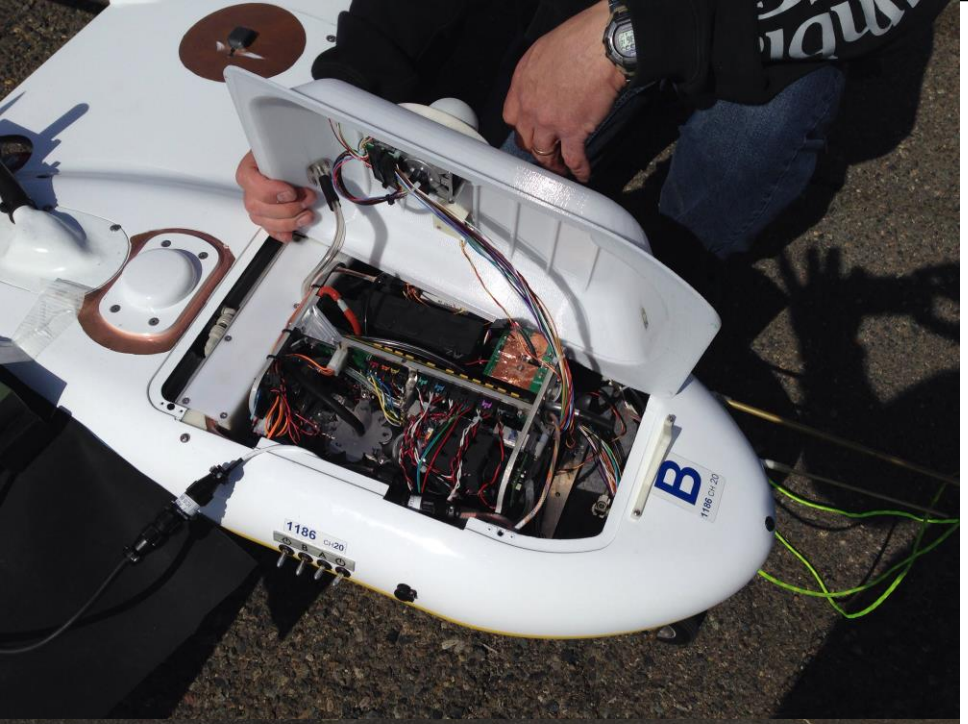
Svalbard, Norway - April 2011 & 2015 – with Russian and Norwegian partners

April 2011:
18 Flights
38 Flight hours

April 2015:
26 Flights
31.8 Flight hours

Ny-Alesund, Svalbard, Norway – near 80N in the Arctic Ocean



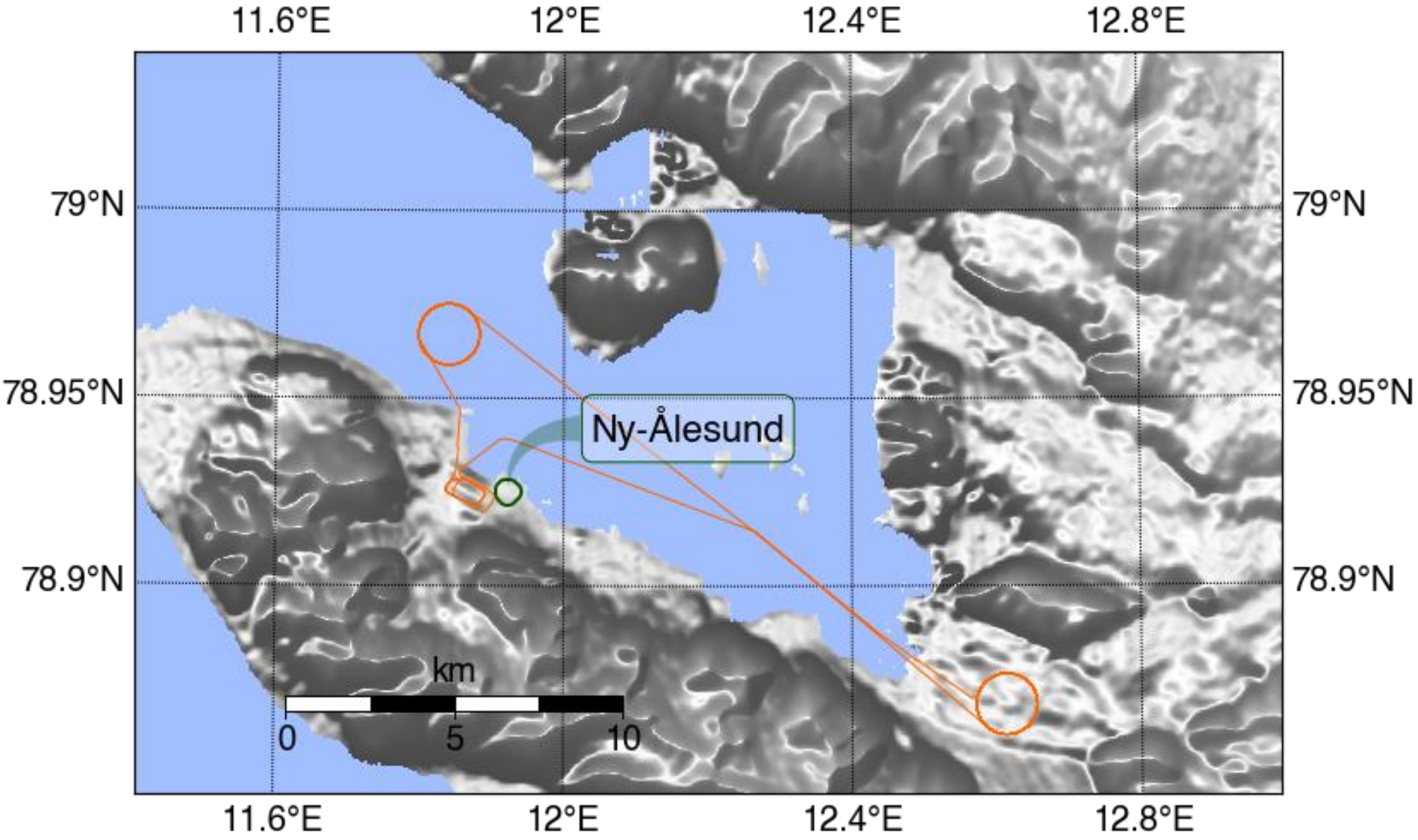


Aerosol Payload Measurements

- Total particle number
- Aerosol light absorption (black carbon)
- Aerosol size distribution (calculated scattering and single scattering albedo) (POPS)
- Filter samples for post-flight chemical analysis
- Temperature/RH/wind direction
- Radiant flux densities (miniSASP)

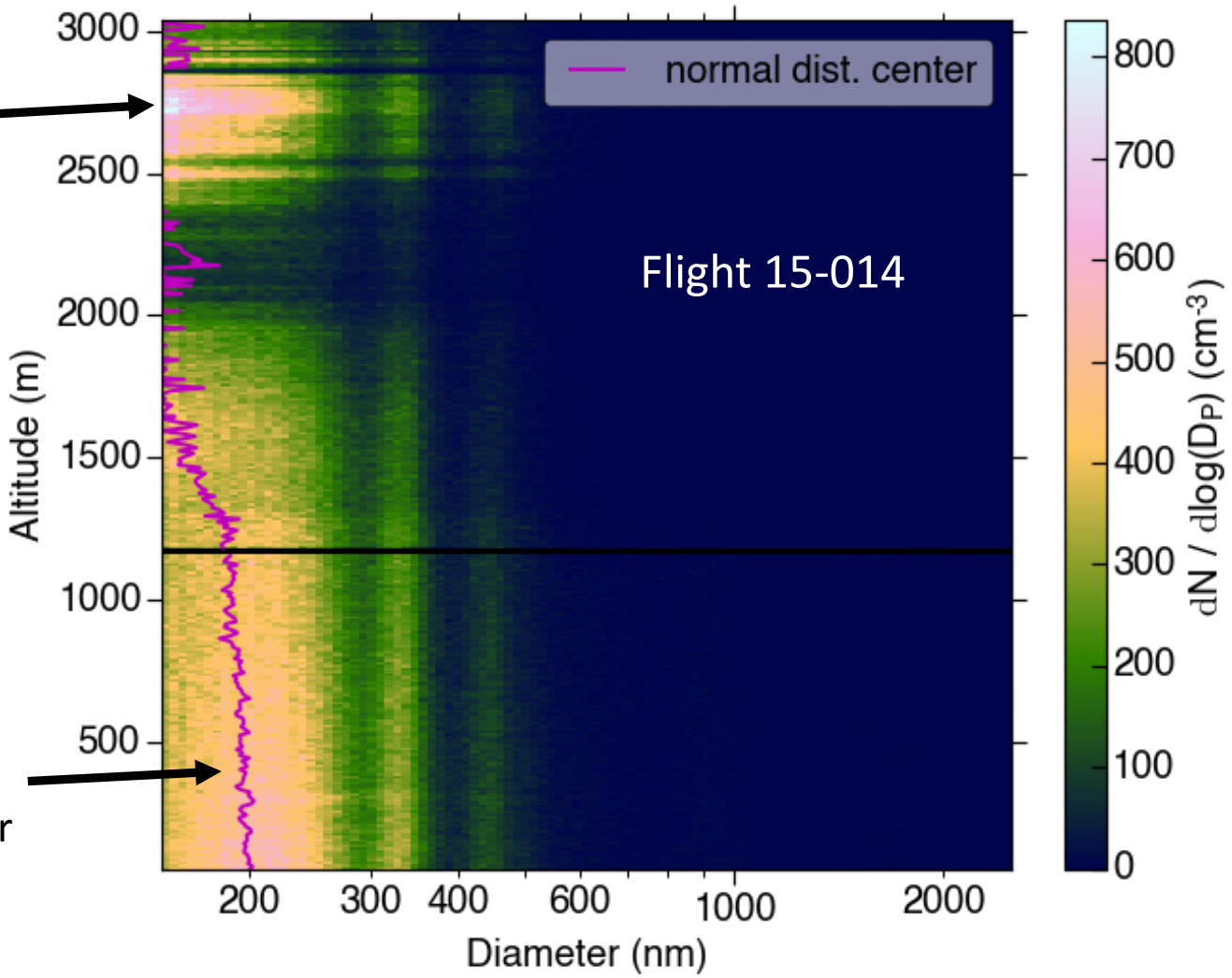
UW/JISAO, NOAA/PMEL & NOAA/ESRL/CSD
Brechtel Manufacturing

Fjord and Glacier Spiral Flight Path



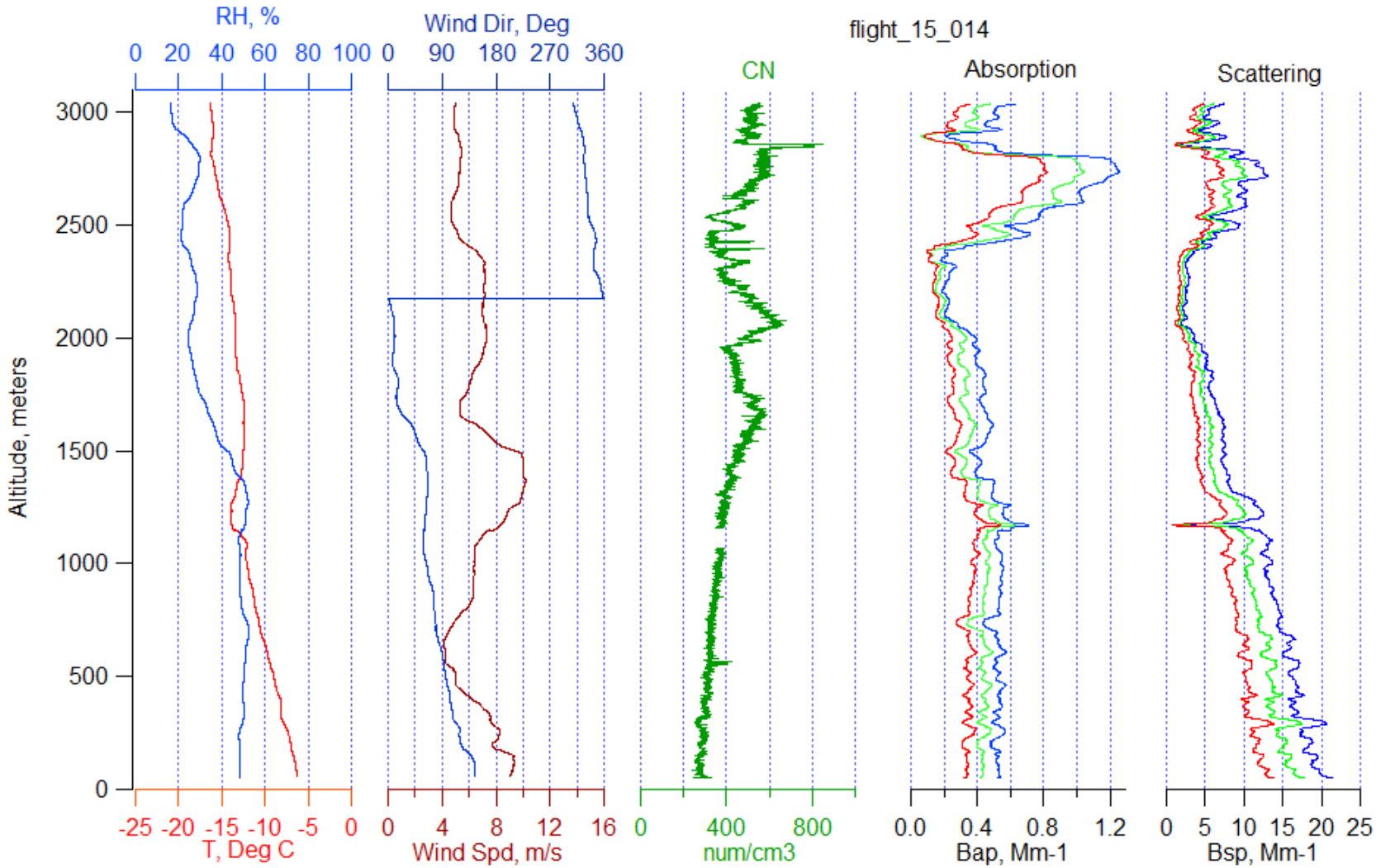
Vertical profile of the aerosol number size distribution: ESRL/CSD's POPS

Upper atmosphere:
Another aerosol layer

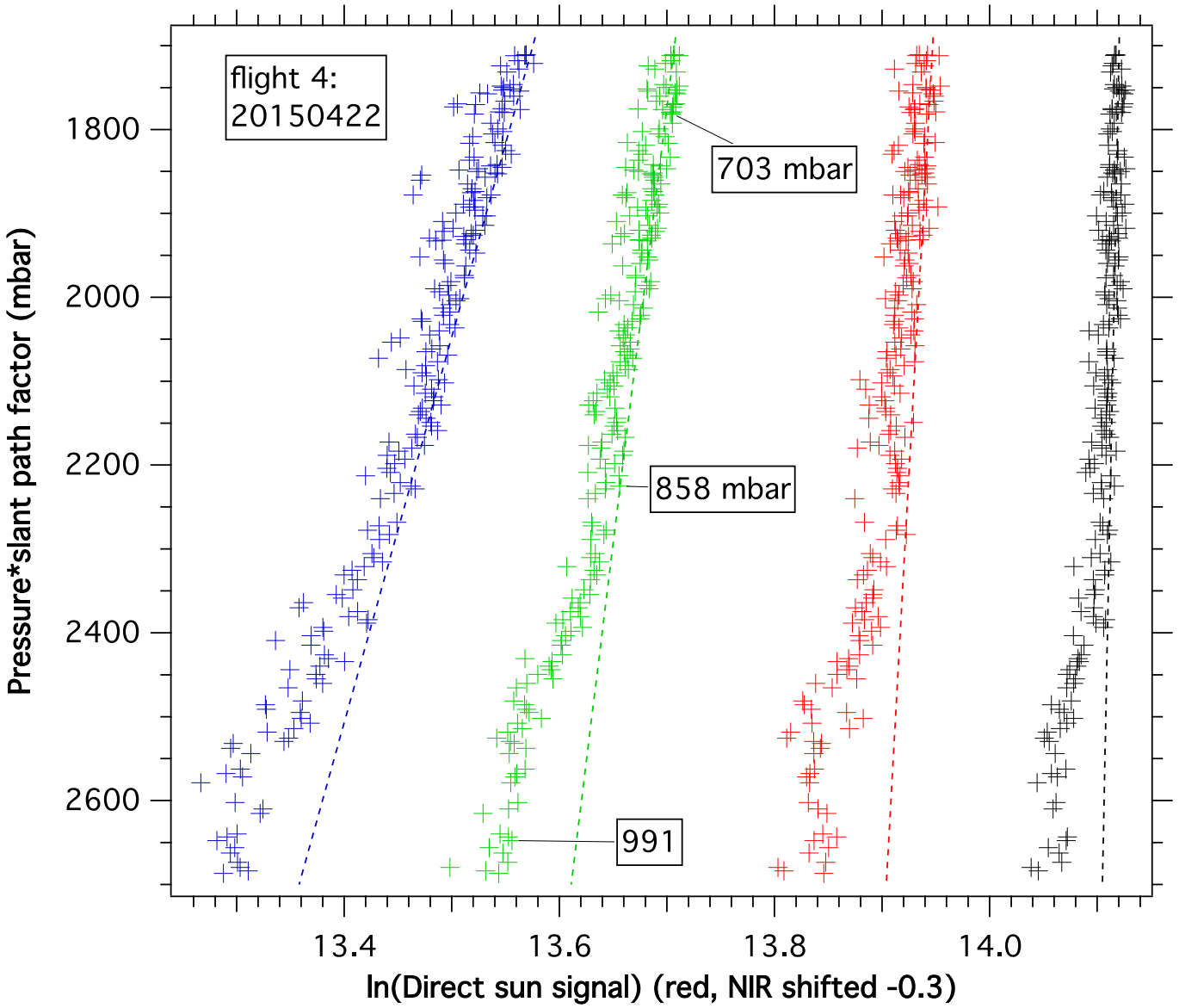


Lower atmosphere:
200 nm modal diameter

RH, Wind, Particle Number Concentration, Absorption, Scattering: PMEL's Aerosol Payload



Aerosol Optical Depth: ESRL/CSD's Miniature Scanning Sun Photometer



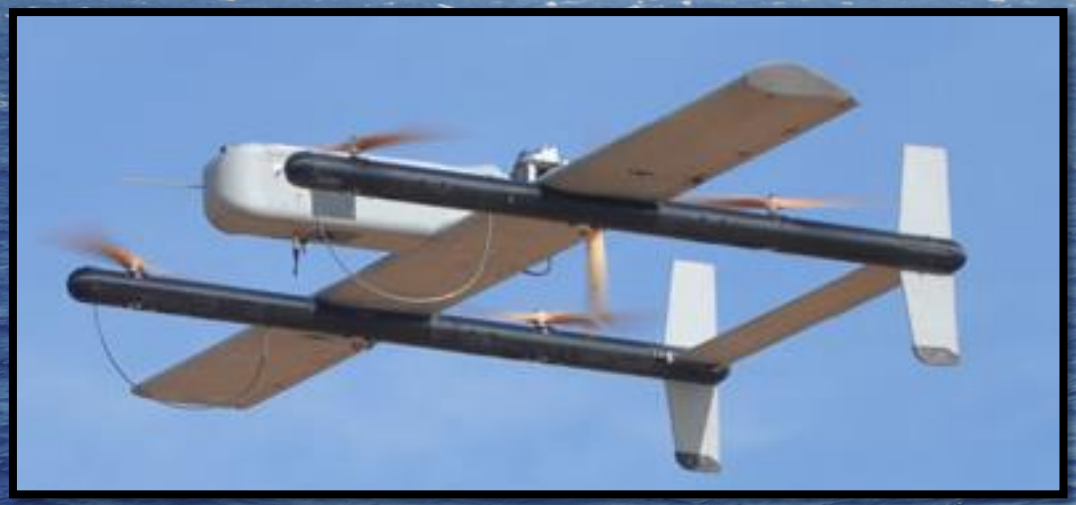
Deviation from straight dashed line indicates aerosol light extinction

Shipboard Launch and Recovery of Unmanned Aerial Systems with 10 kg Payload Capabilities

Step 1: Demonstrate Vertical Take Off and Landing (VTOL), Fixed Wing (FW) Flight Technology from a NOAA ship

Hybrid Quadrotor (HQ) Technology

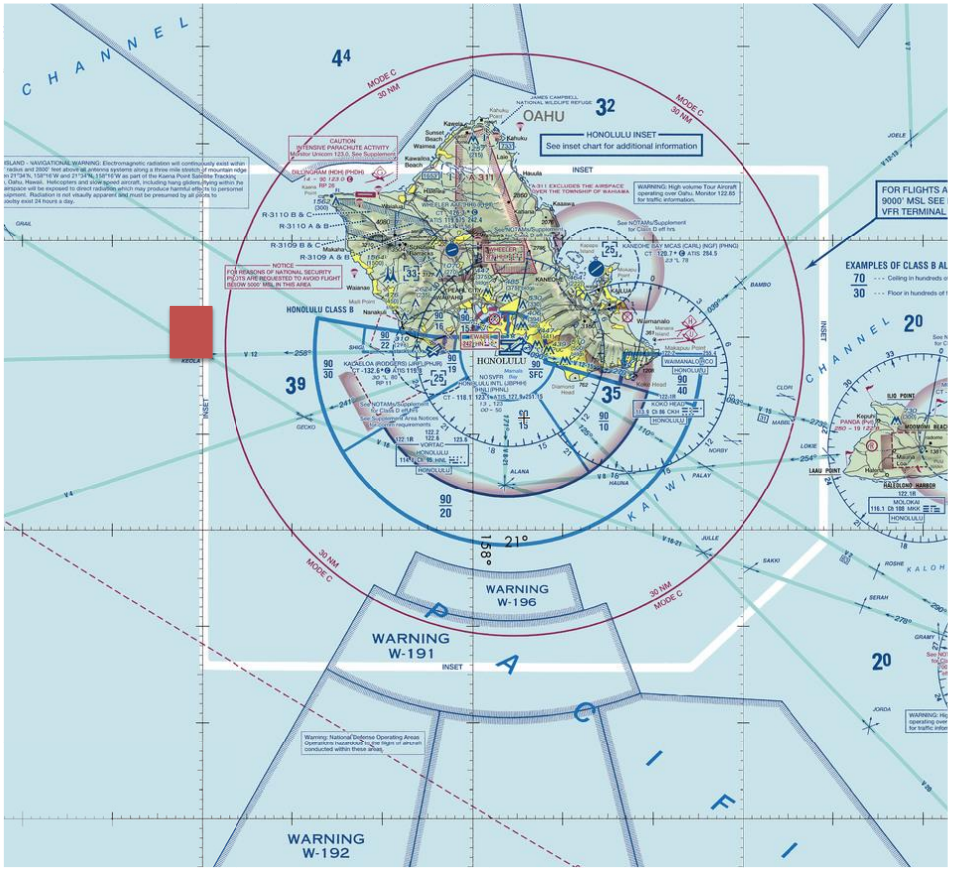
Combines vertical takeoff and landing (VTOL) capabilities of a quadrotor and the speed and range of a fixed-wing aircraft

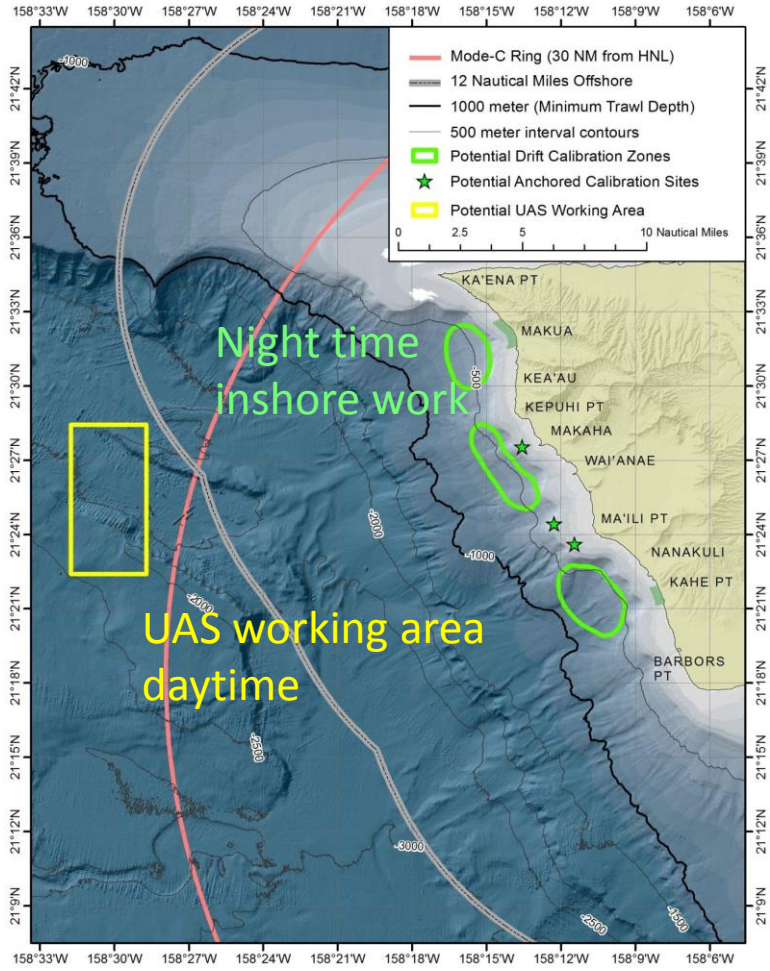


- No runway needed
- Portable
- Shipboard operation possible
- Pusher engine – required for gas and aerosol measurement
- Nose cone payload

Current Latitude Engineering Products:

	HQ-40	HQ-60
Payload:	5 lb	8 – 12 lb
Endurance:	5 hrs	12 – 24 hrs





Operating area (yellow rectangle) west of Oahu outside the Mode C ring and 35 nm from shore. The ship worked close to shore at night in the green ovals.

Operational Limits

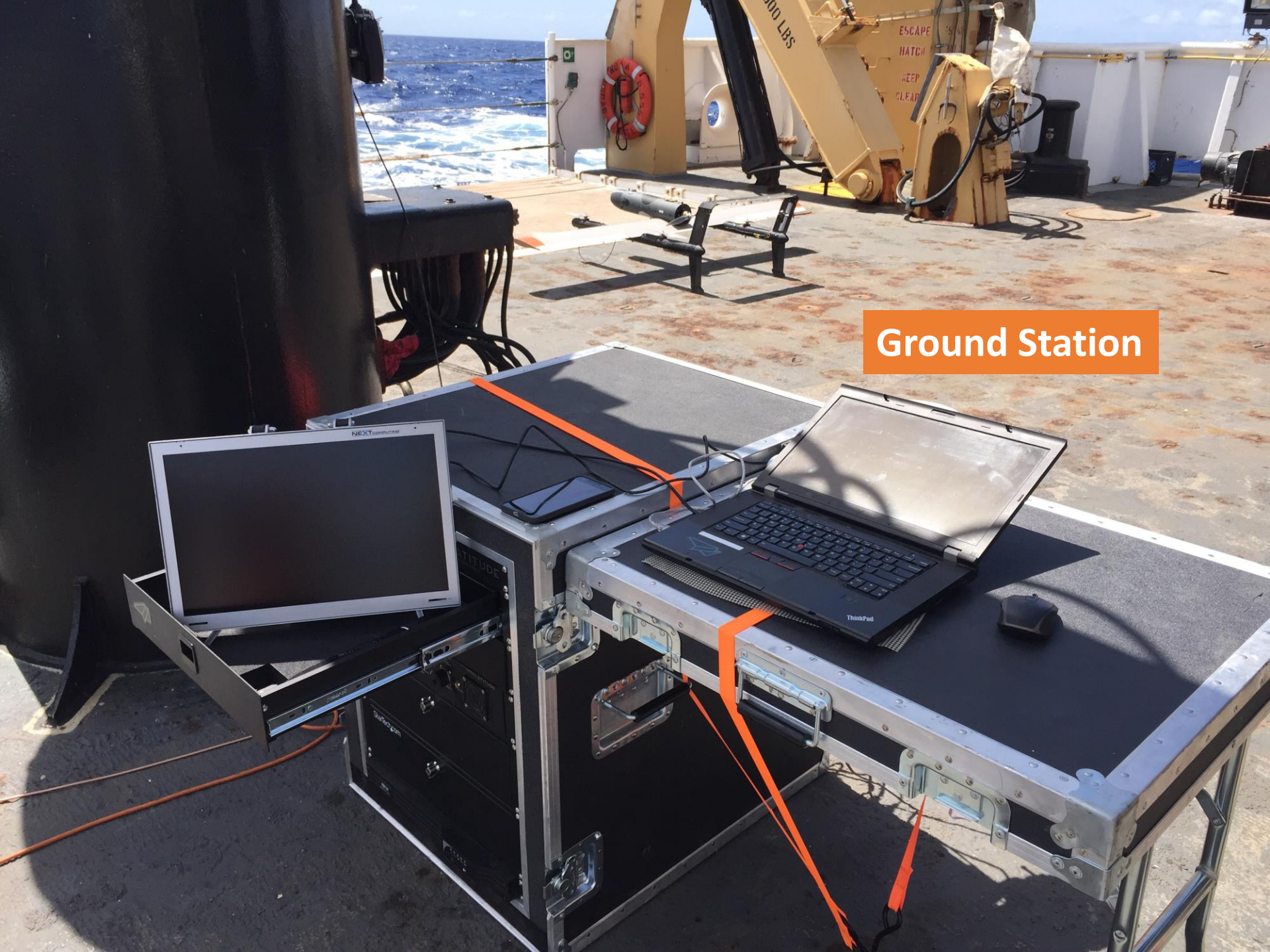
Range: Operations were limited to daytime and line of sight.

Altitude: Operations were limited to below 1000 ft.

Wind and Sea State: Operations were limited to wind speeds less than 30 knots (Beaufort 6 or above).

Clouds and Visibility: Operations were limited to visual line of sight and class E airspace weather minimums (3 statute miles flight visibility and 500 ft below any clouds).

HQ-20 on the fantail. The HQ-20 is a 25 lb, all electric VTOL fixed wing UAS. It is designed to be an inexpensive, highly ruggedized test vehicle for flight control software testing. It is capable of 10 minutes of vertical mode flight and 10 minutes of fixed wing flight.


Ground Station

HQ-20 Hover Test

Progressed from hovering just off the deck to 15 feet above the deck.

HQ-20 transitioning from HQ to FW flight

HQ20 Launch : June 19, 2016
Wind speed 10 – 15 knots, Seas 2 – 4 feet

HQ20 Recover : June 19, 2016
Wind speed 10 – 15 knots, Seas 2 – 4 feet

Accomplishments

- 5 successful hover flights
- 4 successful flights with vertical take off, switch to fixed wing flight, and vertical landing.
- Successful flights were conducted with takeoff toward the stern and wind on the stern.
- Demonstrated the ability to operate the HQ technology from a ship with limited deck space.
- Demonstrated the ability to operate the HQ technology from a ship under 10 – 18 kt wind speed conditions.

Lessons learned

- Pitch and roll of the deck posed a less significant challenge than anticipated.
- The large steel structure of the ship was significant enough to cause a large interference with the magnetometer. Autonomous landing will require another approach. Latitude Engineering is exploring the use of a downward looking camera and a calibrated target fixed to the deck to guide the UAS while in VTOL mode near the flight deck. This method does not require expensive and heavy differential GPS and aids the magnetometer while in close proximity to the ship.
- Take off with the bow of the ship into the wind, with wind speeds of 20 kts, resulted in significant superstructure related turbulence that overpowered the HQ motors. Latitude Engineering plans to increase the VTOL system control authority (power, responsiveness) for future shipboard operations.

Next steps

- These tests should be repeated when Latitude Engineering is ready to demonstrate autonomous take offs and landings with the HQ-20 without use of the magnetometer.
- After successful autonomous operations with the HQ-20 have been demonstrated, test flights should be performed with a larger HQ aircraft capable of carrying a 10 kg payload.

Latitude Engineering is currently on the SOI Falkor with plans to fly the HQ-60 with camera payloads with manual take offs and landings.